

In re Patent Application of:
RIZZOTTO ET AL.
Serial No. 10/615,446
Filing Date: JULY 8, 2003

In the Claims:

Claims 1-10 (Cancelled).

11. (Currently Amended) A method of operating a quantum gate running ~~performing~~ a Grover's quantum algorithm ~~receiving a binary function having a basis of vectors of n qubits,~~ the method comprising:

receiving at an input of the quantum gate a binary function having a basis of vectors of n qubits;

carrying out a superposition operation using a superposition subsystem coupled to the input, the superposition operation being carried out on input vectors for generating components of linear superposition vectors based upon a second basis of vectors of $n+1$ qubits;

carrying out an entanglement operation using an entanglement subsystem coupled to the superposition subsystem, the entanglement operation being carried out on components of the linear superposition vectors for generating components of numeric entanglement vectors, the entanglement operation generating, for components of each superposition vector, corresponding components of a numeric entanglement vector, each component based upon a respective vector of the second basis and being equal to one of the following

the corresponding component of the respective superposition vector if the binary function is null based upon the vector of the first basis formed by the first n qubits of the respective vector of the second basis, and

the opposite of the corresponding component of the respective superposition vector if the binary

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function is not a null; and
carrying out an interference operation using an
interference subsystem coupled to the entanglement subsystem,
the interface operation being carried out on components of the
numeric entanglement vectors for generating components of
output vectors.

12. (Previously Presented) A method according to
Claim 11, wherein the components of each output vector are
even components, and odd components of each output vector are
obtained by inverting the even components.

13. (Previously Presented) A method according to
Claim 11, wherein the components of each output vector are odd
components, and even components of each output vectors are
obtained by inverting the odd components.

14. (Previously Presented) A method according to
Claim 11, wherein even or odd components of a numeric
entanglement vector are obtained by carrying out the following
operations:

encoding components of each linear superposition
vector with a low logic value if negative and with a high
logic value if positive for generating components of encoded
superposition vectors;

generating for components of each encoded
superposition vector corresponding components of an encoded
entanglement vector, each component based upon a respective
vector of the second basis and being obtained by

copying the corresponding component of the

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respective encoded superposition vector if the binary function is null in correspondence to the vector of the first basis formed by the first n qubits of the respective vector of the second basis, or

logically inverting the corresponding component of the respective encoded superposition vector if the binary function is not a null; and
decoding the components of encoded entanglement vectors for generating the components of numeric entanglement vectors.

15. (Previously Presented) A method according to Claim 14, wherein each of the components of an encoded entanglement vector is obtained by XORing the corresponding component of the encoded superposition vector with a value of the binary function corresponding to the vector of the first basis formed by the first n qubits.

16. (Previously Presented) A method according to Claim 11, wherein the interference operation comprises:
calculating a weighed sum with a scale factor of even or odd components of a numeric entanglement vector; and
generating each even or odd component of an output vector by respectively subtracting a corresponding even or odd component of a numeric entanglement vector from the weighed sum.

17. (Currently Amended) A method of operating a quantum gate running ~~performing~~ a Deutsch-Jozsa's quantum

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~~algorithm receiving a binary function having a basis of~~
~~vectors of n qubits,~~ the method comprising:

receiving at an input of the quantum gate a binary
function having a basis of vectors of n qubits;

carrying out a superposition operation using a
superposition subsystem coupled to the input, the
superposition operation being carried out on input vectors for
generating components of linear superposition vectors based
upon a second basis of vectors of $n+1$ qubits;

carrying out an entanglement operation using an
entanglement subsystem coupled to the superposition subsystem,
the entanglement operation being carried out on components of
the linear superposition vectors for generating components of
numeric entanglement vectors, the entanglement operation
generating, for components of each superposition vector,
corresponding components of a numeric entanglement vector,
each component based upon a respective vector of the second
basis and being equal to one of the following

the corresponding component of the respective
superposition vector if the binary function is null
based upon the vector of the first basis formed by
the first n qubits of the respective vector of the
second basis, and

the opposite of the corresponding component of
the respective superposition vector if the binary
function is not a null; and

carrying out an interference operation using an
interference subsystem coupled to the entanglement subsystem,
the interface operation being carried out on components of the
numeric entanglement vectors for generating components of

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output vectors.

18. (Previously Presented) A method according to Claim 17, wherein the components of each output vector are even components, and odd components of each output vector are obtained by inverting the even components.

19. (Previously Presented) A method according to Claim 17, wherein the components of each output vector are odd components, and even components of each output vectors are obtained by inverting the odd components.

20. (Previously Presented) A method according to Claim 17, wherein even or odd components of a numeric entanglement vector are obtained by carrying out the following operations:

encoding components of each linear superposition vector with a low logic value if negative and with a high logic value if positive for generating components of encoded superposition vectors;

generating for components of each encoded superposition vector corresponding components of an encoded entanglement vector, each component based upon a respective vector of the second basis and being obtained by

copying the corresponding component of the respective encoded superposition vector if the binary function is null in correspondence to the vector of the first basis formed by the first n qubits of the respective vector of the second basis,
or

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logically inverting the corresponding component of the respective encoded superposition vector if the binary function is not a null; and decoding the components of encoded entanglement vectors for generating the components of numeric entanglement vectors.

21. (Previously Presented) A method according to Claim 20, wherein each of the components of an encoded entanglement vector is obtained by XORing the corresponding component of the encoded superposition vector with a value of the binary function corresponding to the vector of the first basis formed by the first n qubits.

22. (Previously Presented) A quantum gate for running a Grover's quantum algorithm and comprising:
an input for receiving a binary function having a basis of vectors of n qubits;
a superposition subsystem connected to the input for carrying out a superposition operation on components of input vectors for generating components of linear superposition vectors based upon a second basis of vectors of $n+1$ qubits;
an entanglement subsystem connected to said superposition subsystem for carrying out an entanglement operation on components of the linear superposition vectors for generating components of numeric entanglement vectors, said entanglement subsystem comprising
a command circuit generating a plurality of logic command signals encoding values of the binary function corresponding to the vectors of the first

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basis, and

circuit means being input with the logic command signals and generating for components of each superposition vector corresponding signals representing components of a numeric entanglement vector, each component referred to a respective vector of the second basis is equal to at least one of the following

the corresponding component of the respective superposition vector if the binary function is null in correspondence to the vector of the first basis formed by the first n qubits of the respective vector of the second basis, and

the opposite of the corresponding component of the respective superposition vector if the binary function is not a null;
and

an interference subsystem connected to said entanglement subsystem for carrying out an interference operation on components of the numeric entanglement vectors for generating components of output vectors.

23. (Previously Presented) A quantum gate according to Claim 22, wherein said circuit means encodes components of each linear superposition vector with a low logic value if negative and with a high logic value if positive for generating signals representing components of an encoded superposition vector, said circuit means comprising:

an array of XOR logic gates each input with a signal

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representing a component of an encoded superposition vector,
and with a relative logic command signal for generating
voltage signals representing components of encoded
entanglement vectors; and

an array of digital/analog converters that decodes
components of the encoded entanglement vectors for generating
signals representing corresponding components of numeric
entanglement vectors.

24. (Previously Presented) A quantum gate according
to Claim 23, wherein each digital/analog converter outputs a
signal representing the weighed difference with a second scale
factor between the component of encoded entanglement vectors
and a reference value.

25. (Previously Presented) A quantum gate according
to Claim 22, wherein said interference subsystem comprises:

an adder being input with voltage signals
representing even or odd components of a numeric entanglement
vector, and generating a summed signal representing a weighed
sum with a scale factor of the even or odd components; and

an array of adders each being input with a
respective signal representing an even or odd component,
respectively, of a numeric entanglement vector and with the
summed signal for generating a signal representing an even or
odd component, respectively, of the output vector as the
difference between the summed signal and the signal
representing an even or odd component of a numeric
entanglement vector.

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26. (Previously Presented) A quantum gate for running a Deutsch-Jozsa's quantum algorithm and comprising:
an input receiving a binary function having a basis of vectors of n qubits;

a superposition subsystem connected to the input for carrying out a superposition operation on components of input vectors for generating components of linear superposition vectors based upon a second basis of vectors of $n+1$ qubits;

an entanglement subsystem connected to said superposition subsystem for carrying out an entanglement operation on components of the linear superposition vectors for generating components of numeric entanglement vectors, said entanglement subsystem comprising

a command circuit generating a plurality of logic command signals encoding values of the binary function corresponding to the vectors of the first basis, and

a circuit being input with the logic command signals and generating for components of each superposition vector corresponding signals representing components of a numeric entanglement vector, each component referred to a respective vector of the second basis is equal to at least one of the following

the corresponding component of the respective superposition vector if the binary function is null in correspondence to the vector of the first basis formed by the first n qubits of the respective vector of the second basis, and

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the opposite of the corresponding
component of the respective superposition
vector if the binary function is not a null;
and

an interference subsystem connected to said
entanglement subsystem for carrying out an interference
operation on components of the numeric entanglement vectors
for generating components of output vectors.

27. (Previously Presented) A quantum gate according
to Claim 26, wherein said circuit encodes components of each
linear superposition vector with a low logic value if negative
and with a high logic value if positive for generating signals
representing components of an encoded superposition vector,
said circuit comprising:

an array of XOR logic gates each input with a signal
representing a component of an encoded superposition vector,
and with a relative logic command signal for generating
voltage signals representing components of encoded
entanglement vectors; and

an array of digital/analog converters that decodes
components of the encoded entanglement vectors for generating
signals representing corresponding components of numeric
entanglement vectors.

28. (Previously Presented) A quantum gate according
to Claim 27, wherein each digital/analog converter outputs a
signal representing the weighed difference with a second scale
factor between the component of encoded entanglement vectors
and a reference value.